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Assessing the Risk of a Substantial Increase in Long-term Interest Rates

Stefania D'Amico, James Egelhof, Steve Friedman, Mike Kiley, Don Kim, Marcel Pribsch, Matt Raskin, Francisco Vazquez-Grande, and Min Wei

1. Introduction

This memo considers the risk of a substantial increase in long-term interest rates. Our objective is to shed light on the possibility of an increase that would be big relative to baseline expectations, and so could cause meaningful investor losses. While any definition of a “substantial increase” is inherently arbitrary, we have in mind outcomes in which the 10-year Treasury yield at the end of 2014 reaches levels roughly 100 or 200 basis points above expectations of market participants or the staff’s projection. The sizes of these prospective increases are broadly consistent with those in the “high interest rate scenarios” included in staff balance sheet and income projections.¹

We begin with a basic decomposition of long-term Treasury yields and conceptual discussion of the potential drivers of a substantial increase in the components thereof. We then use information from three sources—surveys, financial asset prices, and staff models—to quantify the likelihood of various outcomes for long-term rates at the end of 2014. While each of these sources has shortcomings, together they help to usefully dimension the risks. Next, we review two historical episodes, 1994 and 2003-2004, using similarities and differences across those episodes to illuminate the current risks. Finally, we consider the ways in which current monetary policy tools—forward rate guidance with numerical thresholds and flow-based asset purchases linked to the labor market outlook—serve to amplify or reduce the risks of a substantial increase in rates.

Our findings can be summarized as follows:

- Information from the various sources indicates that the risk of an increase in long-term rates to levels 100 to 200 basis points above the staff’s baseline projection is notable but not elevated from a historical perspective, although historical comparisons are complicated by the novelty of the current policy environment. Indeed, the enhanced FOMC communications seem likely to contribute to a somewhat lower risk of a sharp upward movement in long-term yields than might otherwise have been the case.

¹ See Alyssa Cambron, Michelle Ezer, Andrew Figura, Josh Frost, Jeff Huther, Jane Ihrig, John Kandrak, Don Kim, Beth Klee, Debby Leonard, Dave Reifschneider, Julie Remache, John Roberts, Min Wei, and Nate Wuerffel, “Options for Continuation of Open-Ended Asset Purchases in 2013,” memo sent to the Committee on November 30, 2012.

- As best we can judge, asset prices indicate a slower expected rise in long-term interest rates than the staff projects, partly reflecting the fact that market participants appear to anticipate a larger purchase program than the staff assumed in January. The differences between market quotes and staff expectations accounts for an important part of the discrepancy between confidence intervals based on market quotes and those conditioned on the staff projection; if market quotes and staff projections for yields were to converge, perhaps reflecting greater clarity regarding the current purchase programs, market quotes and staff models would likely imply a broadly similar potential for an increase in long-term rates relative to their respective baselines.
- At the initiation of earlier tightening episodes, uncertainty about monetary policy appears to have been a key determinant of the reaction of long-term rates to policy tightening.
- While threshold-based guidance for the federal funds rate and the conditionality of asset purchases to economic outcomes could, in principal, amplify the volatility of rates in response to incoming information, we do not find evidence for such dynamics to date. The Committee's expanded communications toolkit should help mitigate the risks of an unexpectedly sharp movement in long-term rates. On the other hand, the current policy mix, involving both threshold-based forward guidance and shifts in the size and composition of the balance sheet, is unprecedented, and the Committee may find it challenging to communicate its plans regarding the removal of accommodation without incurring some degree of confusion among market participants.

2. What Could Trigger a Substantial Increase in Long-Term Rates?

A long-term Treasury yield can be decomposed into three components: the expected path of short-term real interest rates, expected inflation, and a term premium. While developments that affect any one of these components are likely to affect the others as well, considering them individually—as we do below—helps to shed light on earlier episodes when long-term rates increased substantially, as well as the potential contribution of monetary policy and other factors to the risk of an outsized increase today.

First, long-term interest rates could rise because of a shift in *expectations for the path of short-term real interest rates*. Currently, according to the January Primary Dealer Survey, the nominal policy rate is expected to remain in its current range of 0 to 1/4 percent until the first half of 2015, and then to rise gradually thereafter, by a bit more than 100 basis points per year through late 2017. Survey respondents also expect headline PCE inflation to come in at 1.7 percent in 2013 and 2.0 percent thereafter. As a result, according to this survey, market participants appear to expect that the real policy rate will be in the range of -1.5 percent in the current year, -1.8 percent through the first half of 2015, and then gradually higher (towards zero) thereafter.

The expected timing of the first increase in the target rate from the dealer survey has remained constant since September 2012, although the pace of tightening after liftoff has declined a bit in

recent months. Inflation expectations from this survey have fluctuated modestly over the past several months, remaining around mandate-consistent levels. As a result, expectations for the real policy path have remained fairly little changed since the September meeting at highly accommodative levels. Notably, these policy expectations have remained steady despite a considerable improvement in survey expectations for the unemployment rate over the next two years.

A shift higher in the expected path of the real policy rate would most likely stem from an event that led market participants to expect less policy accommodation than they currently do. For example, the economy might start to improve more quickly than investors had anticipated, leading to a commensurate revision to expectations for the timing of liftoff or the pace of increase following liftoff. An unanticipated rise in inflation or inflation expectations might also cause market participants to expect the FOMC to hasten the withdrawal of accommodation, as could a perception that the FOMC would act to address costs of policy accommodation or financial stability fears. Market participants might also conclude that their estimate of the FOMC's reaction function, independent of underlying fundamentals, was incorrect, perhaps due to communications they perceive to be new, unclear, or non-credible, or a change in Committee membership. Uncertainty related to the reaction function may be of particular importance, as the Committee's current forward guidance, while extensive, does not fully specify its actions in all scenarios at all times, and in particular there remains considerable uncertainty about the timing and pace of exit.

FOMC communications regarding future policy can, to an extent, mitigate the associated risks. For example, the numerical thresholds adopted by the Committee in December 2012 should help investors more readily update their policy rate expectations in response to economic news than was the case under the prior date-based guidance. While such updating could imply greater sensitivity to incoming information on economic conditions, it may also serve to reduce the likelihood that investor expectations will stray too far from the likely policy rate path and move sharply as they catch up.² The Committee can also communicate about the pace at which it is likely to remove accommodation once it begins to do so. Nevertheless, a significant and unanticipated improvement in the economy might still lead investors to question the Committee's willingness to stick to the numerical thresholds or to tighten only gradually after liftoff, particularly if the improvement were accompanied by an increase in inflation and inflation expectations.

Second, it is possible that *inflation expectations* could shift notably higher at some point and precipitate a sharp movement in long-term interest rates. This could occur, for example, if realized inflation were to run above mandate-consistent levels for a long time, if investors began

² Interestingly, as we discuss below, the evidence to-date does not suggest that the thresholds have increased the sensitivity of short-rate expectations to macroeconomic data surprises.

to doubt the willingness of the Committee to return inflation to mandate-consistent levels over the medium term, or if market participants were to come to think that the level of policy accommodation or the size of the balance sheet were too large to carry out a successful exit or were otherwise inconsistent with price stability. However, survey measures indicate that inflation is expected to remain steady near mandate-consistent levels, and surveys report that long-term inflation expectations have been very stable over the last two decades. Inflation compensation derived from TIPS and related financial markets also suggest that inflation expectations are well-anchored. In addition, experience in the UK and in Japan suggests that long-run inflation expectations may be slow to change despite long periods of above- or below-mandate inflation.

Third, long-term interest rates could rise because of an increase in *term premiums*; at -60 basis points according to the Board staff's standard three-factor model, the 10-year term premium remains near historically low levels.³ An increase in the term premium could occur if expectations for the future path of Federal Reserve securities holdings shifted down, uncertainty about the future path of the target rate or Federal Reserve securities holdings rose, or other factors suppressing the term premium, such as Europe-related risks, dissipated. It could also occur if the inflation risk premium, which is a component of the nominal term premium and reflects compensation for assuming inflation risk, were to rise because of an increase in inflation uncertainty. Absent unexpected shocks, the eventual end of flow-based asset purchases in a manner consistent with market expectations should not result in large and rapid movements in term premiums, as their current level of term premium should already reflect those expectations.

It is important to note that these components may move in the same direction, or in different directions, depending on the type of shock that takes place. For example, if the economic outlook improves and market participants come to expect a smaller asset purchase program, they may also expect an earlier start to, and faster pace of, conventional policy tightening. In this scenario, the real policy expectations and term premium components of long-term rates likely would rise in tandem. Alternatively, a decision to end asset purchases due to cost considerations, before a substantial improvement in the labor market outlook is achieved, could lead investors to expect a weaker economic outlook and lower short-term real policy rate path. This would push against the higher term premiums coming from the earlier-than-expected end to asset purchases.

Certain market dynamics could either dampen or amplify an initial rise in interest rates associated with an increase in any of the three components discussed above. One important consideration is the duration-extension risk that mortgage investors face as rates rise, and how actively the universe of mortgage investors would hedge this risk. The Federal Reserve now holds a large portion of outstanding agency MBS and does not actively hedge the associated prepayment risk, and there has been a significant decline in the portion of agency MBS held by

³ Alternative measures of term premium provide a similar qualitative assessment.

the housing GSEs, which do actively hedge. As a result, amplification effects related to MBS convexity hedging may be less pronounced today than in earlier episodes in which long-term rates increased substantially. Conversely, recent increases in holdings of MBS by agency REITs could amplify an initial increase in rates. Some market participants believe that these investors may face a reduced willingness of repo lenders to provide financing in a rising rate environment, prompting MBS sales at a time when dealers and other investors would also likely be looking to reduce their own exposure to duration risk.

The price-sensitivity of other key fixed-income investors, including their likely response to mark-to-market fluctuations in asset prices, could also influence the risk that a rise in interest rates becomes disorderly. For example, foreign ownership of Treasury securities has risen notably since the 1994 episode discussed below, and much of this increase is due to foreign reserve accumulation by central banks and other reserve managers. These investors are relatively less price-sensitive, and face a limited set of alternatives when considering shifts in their holdings. In addition, if the recovery were to strengthen, emerging market economies would likely experience continued capital inflows, and assuming these countries continue their current policies, the associated reserve accumulation may serve as a source of demand for Treasuries even as interest rates rise.

In a rapidly rising rate environment, dealer willingness to provide balance sheet as some investors reduce exposure to duration risk could also influence market liquidity and whether a transition to higher interest rates would remain orderly. Many investors have noted that since the financial crisis, dealers have been less willing to provide liquidity to financial markets during times of stress or high volatility, particularly for credit instruments. For example, in August 2011, as investors contended with growing concerns over European banking sector and sovereign risks as well as S&P's downgrade of the U.S. government obligations, credit market conditions became highly illiquid as dealers largely stepped back from active market making in corporate debt markets.

3. How Large is the Risk of a Substantial Increase in Long-Term Rates?

Overall, market participants and private-sector forecasters, as well as the staff, expect a steady but gradual rise in long-term interest rates over the next several years. For example, according to the March 2012 Blue Chip Economic Indicators survey, the consensus expectation for the average value of the 10-year Treasury yield over the fourth quarter of 2014 is 2.9 percent, approximately 100 basis points above recent levels of the 10-year yield.⁴ A staff term structure model discussed below, which takes explicit account of the zero lower bound (ZLB), generates a similar forecast. In comparison, in the January Tealbook the staff projected a somewhat larger rise in the 10-year Treasury yield over this period, to about 3.5 percent at the end of 2014. A

⁴ Survey responses were submitted on March 4-5. Survey results will be released to the public on Monday, March 11, 2013.

part of the difference between the survey forecast and the staff forecast can be attributed to the fact that market participants appear to anticipate a larger purchase program than the staff assumed in January.⁵ On the other end of the spectrum, forward 10-year Treasury and swap rates at the end of 2014 are significantly lower, with both currently near 2.6 percent. These lower levels likely stem in part from the fact that, unlike the Blue Chip and staff models, the forward rates embed a negative term premium. Chart 1 compares the forecast paths from these sources over the years 2013 to 2015.

While central expectations appear to be for a measured increase in long-term rates over the next several years, an assessment of the risk of a rise in long-term rates must take account of the uncertainty around these expectations. One source of information on the distribution of market participants' expectations for future long-term rates is the dispersion of survey forecasts. In the same Blue Chip survey as mentioned above, the ten lowest forecasts and the ten highest forecasts for the 10-year rate at the end of 2014 average about 2.3 and 3.5 percent, respectively. Another source of information is swaptions.⁶ As shown in Chart 2, swaptions currently imply that the upper bounds of the "risk-neutral" 70- and 90-percent confidence intervals for the 10-year swap rate at the end of 2014 are about 3.6 percent and 4.6 percent, respectively.⁷ Assuming that the spread between the 10-year swap rate and Treasury yield is expected to follow the path implied by the forwards, these upper bounds correspond to increases in the 10-year Treasury yield of approximately 150 basis points and 250 basis points, respectively, over the next two years.⁸

The distribution of future long-term interest rates conditioned on the staff's assessment of economic and financial conditions can also be judged using the FRB/US model. One advantage of doing so is that the assessment of outcomes for long-term rates is then consistent with other forecast material produced by the staff. The FRB/US-implied upper bounds of the 70- and 90-percent confidence intervals for the 10-year Treasury yield at the end of 2014 are 4.4 percent and 5 percent, respectively. The upper-bound of the 70-percent interval is notably above that implied

⁵ In particular, the median forecast from the January Primary Dealer Survey indicates additional \$1080 billion purchases of longer-term securities beyond 2012, while the January Tealbook assumed purchases totaling about \$510 billion. The forecasted policy rate paths from the two sources are much more similar, with primary dealers and the staff viewing 2015:Q3 and the end of 2015, respectively, as the mostly likely timing of the first rate increase.

⁶ Swaptions are options that give the buyer the option to pay (or receive) fixed on a LIBOR-based interest rate swap, at a given strike rate on a given future date.

⁷ The "risk-neutral" percentiles are derived under the assumption that the marginal swaption investor is risk-neutral. In reality, swaption prices reflect not only investors' assessments of the likelihood of interest rate outcomes, but also their demand for exposure to those outcomes for hedging or speculation. It is difficult to judge how the "risk-neutral" percentiles relate to the actual percentiles without the use of a pricing model.

⁸ Swaptions reference the 10-year swap rate, not the 10-year Treasury yield. The spread between the 10-year swap rate and 10-year Treasury yield is currently near its all-time low. To the extent that this spread is expected to normalize in coming years, the increases in 10-year yields implied by swaptions would overstate the increases for the 10-year Treasury yield.

by swaptions, reflecting in part the difference in the underlying assumptions regarding the ultimate size of the Federal Reserve's asset purchases. In comparison, the upper-bound of the 90-percent confidence interval is only moderately above that implied by swaptions; after accounting for the differences in central tendencies, the upper-tail of the confidence interval from FRB/US and that from swaptions are not especially dissimilar, and these tails would likely become more similar if the staff projection and market quotes moved into closer alignment, perhaps due to greater clarity about the current purchase program.

A third measure of the distribution of future 10-year Treasury yields comes from a staff term structure model that takes special account of the ZLB. This model currently indicates that the upper bounds of the 70- and 90-percent confidence intervals for the 10-year Treasury yield at the end of 2014 are about 4.0 percent and 4.7 percent, respectively, about halfway between those implied by swaptions and by FRB/US. In addition, estimates of the long-run term premiums from this model are lower than those from the staff's standard three-factor model that ignores the ZLB, suggesting less scope for a large increase in long-term rates as term premiums normalize.

Table 1 summarizes the central expectations and the ranges of forecasts from all four sources. For all but the FRB/US model, we also compare the sizes of the ranges to their historical averages, the results from which suggest that uncertainty about the 10-year yield is slightly lower than its historical average. Chart 3 displays the central tendency and confidence intervals for the 10-year Treasury yield derived from swaptions, stochastic simulations of the FRB/US model, and the term structure model.⁹ To summarize, the models imply that the 85th percentile of the distribution of the 10-year yield at the end of 2014 is between 3.6 and 4.4 percent, while the 95th percentile is between 4.6 and 5.0 percent.¹⁰ Table 2 summarizes the probabilities implied by each model that the 10-year yield at the end of 2014 will exceed the staff's baseline projection of 3.5 percent by more than 100 or 200 basis points. These probabilities of a "substantial increase" relative to the staff's baseline fall between 1 and 13 percent. Similar probabilities for a substantial increase relative to the Blue Chip consensus forecast for 2014:Q4 of 2.9 percent fall between 3 and 36 percent; the higher probabilities reflect the fact a sizable increase in long-term yields relative to the Blue Chip central tendency is very likely according to the staff's January Tealbook projection because of the higher central tendency projected by the staff. Another important point that the table highlights is that the risk to long-term rates is two-sided: the models imply probabilities of 7 to 55 percent that the 10-year yield will be 100 basis points *below* the staff's baseline projection at the end of 2014; indeed, under some approaches, the

⁹ The central tendencies from the swaptions are, by construction, equal to the forward swap rates. In the FRB/US simulations, expectations in financial markets and for wages and prices are model-consistent, following practice in Tealbook B. The federal funds rate is set according to the inertial Taylor (1999) rule, subject to the numerical thresholds for the unemployment rate and projected inflation used in recent FOMC communications. The SOMA portfolio is held at its baseline path.

¹⁰ The 85th and 95th percentiles of the distributions are the upper bounds of the 70- and 90-percent confidence intervals, respectively.

estimated likelihood of a substantial decline in interest rates exceeds that of a substantial increase.

Some concerns regarding the potential for a substantial increase in long-term interest rates arise from the possibility that corporate bond yields could increase sharply. This could lead to a reversal of recent flows into corporate bonds and corresponding amplification of yield increases, given the lower liquidity in the corporate bond market, or to sizable losses for leveraged investors. According to the FRB/US model, confidence intervals for corporate yields are notably wider than those for Treasury yields, reflecting the effects of uncertainty related to corporate bond risk premiums over and above the effects of uncertainty regarding the path of the short-term interest rate and term premiums. In particular, the FRB/US model currently implies that the upper bounds on the 70- and 90-percent confidence intervals for the 10-year BBB-rated corporate bond yield at the end of 2014 are 6.4 and 7.3 percent, respectively, levels that are about 240 and 330 basis points above recent readings of corporate yields.

Overall, it is clear that there is some risk that long-term interest rates could increase substantially more than staff forecasts, although the range of estimates of tail probabilities is considerable. In this regard, it is notable that market expectations for tail risk suggested by swaptions do not suggest that financial markets are showing a marked under-appreciation of the potential for an increase in interest rates. In particular, as noted above, while the upper bound on the FRB/US-implied 70-percent confidence interval lies notably above the upper bound implied by swaptions, the upper bounds on the 90-percent confidence intervals are much closer. That said, looking at confidence intervals provides only a glimpse into possible risks, and the following sections discuss historical episodes and evidence on the effects of recent policy actions that may provide some additional insight into how a substantial rise in longer-term interest rates could play out.

4. Insights from 1994 and 2003-2004

We now turn to an analysis of two episodes in which the FOMC tightened policy after having held the federal funds rate target steady for a substantial period. Our goal is to characterize the responses of long-term interest rates during these episodes, assess the factors that drove them, and highlight implications for the current risks of a substantial rise in long-term rates.

The two episodes are:

- On February 4, 1994, the FOMC raised the federal funds rate target for the first time after the 1990-91 recession; this was followed by additional increases that brought the funds rate target a total of 275 basis points higher over a 12-month period. As shown in Chart 4, the 10-year nominal Treasury yield reacted strongly to the short rate increases, rising 14 basis points on the day of the first increase and about 200 basis points over the next 9 months. Staff models suggest that the increases over this 9-month period reflected both higher expected future short rates and higher term premiums.

- Between June 2003 and June 2004, the FOMC shifted its policy stance: On June 25, 2003, the FOMC reduced the federal funds rate target by 25 basis points, a reduction that was reportedly viewed as less accommodative than expected, as some market participants were said to have anticipated a cut of 50 basis points.¹¹ Transcripts from subsequent FOMC meetings in the summer and fall of 2003 suggest that the smaller-than-expected target rate cut may also have prompted an unwinding of some market expectations for “nontraditional means of conducting open market operations,” though the importance of this factor is difficult to quantify. The 10-year Treasury yield rose 10 basis points on the day and about 125 basis points by early August. Staff models suggest the majority of the increases were due to a higher term premium. Subsequently, the FOMC enhanced its communications, emphasizing in August 2003 that the federal funds rate would remain accommodative for a “considerable period.” Over the first half of 2004, FOMC communications laid the groundwork for a gradual removal of policy accommodation, and, on June 30, 2004, the FOMC raised the federal funds rate target for the first time after the 2001 recession. Subsequent moves resulted in a cumulative 400-basis-point increase in the federal funds rate over the next 24 months. In contrast to the 1994 episode, the 10-year Treasury yield declined 8 basis points on the day of the initial target rate increase—reportedly due to the unexpected retention of the “measured pace” language—and continued to edge lower over the next few months. In retrospect, it appears that a significant portion of the increase in long-term yields that might have been expected from the increase in the federal funds rate over this period occurred during the summer of 2003 when investors revised up significantly their medium-term policy rate expectations; long-term yields fluctuated near the levels reached by August 2003 until early in 2006.

As suggested by the conceptual framework laid out in Section 2, FOMC communications about its policy intentions appears to be a critical factor behind the differential behavior of long-term rates across these three episodes. In particular, in 1994, communications from the FOMC were much less explicit about the outlook for policy than currently, when using forward guidance to help market participants understand the medium-term implications of policy actions has been the norm. FOMC communications at the June 2003 meeting were also less detailed about the outlook for policy than today, although the Committee began to use forward guidance for the federal funds rate in August 2003 (when the Committee indicated it expected rates to remain low for a “considerable period”).

As evidence of the importance of communications during these episodes, surveys suggest that the increases in long-term rates during the 1994 episode and in the summer of 2003 were not associated with higher growth or inflation expectations. As shown in Chart 5, longer-run CPI

¹¹ Fed funds futures contracts ahead of the meeting appear to have priced in a roughly 50 percent chance of a cut of 25 basis points and a 50 percent chance of a cut of 50 basis points.

inflation expectations from the Blue Chip survey were trending down throughout the 1994 episode and held steady in 2003 and 2004, while long-run real GDP growth expectations were flat through the entire sample period. Near-term activity and inflation expectations also did not shift significantly during these periods. For example, from January 1994 through the third quarter of that year, expectations for the unemployment rate over 1995 from the Blue Chip survey barely edged down, although some improvement in expected labor market conditions occurred late in 1994. The role of expectations for economic activity appears even smaller in the short period over which long-term yields rose in the summer of 2003: Between June and August-September 2003, respondents to the Blue Chip survey raised their projections for the unemployment rate over 2004, a factor which, all else equal, would have likely lowered the 10-year Treasury yield.

Instead, substantially higher expectations of the likely future path of short-term rates and uncertainty about that path, both of which may have been related to lack of clarity regarding the Committee's reaction function, are the two main features in 1994 and the summer of 2003. In particular, measures of policy uncertainty one year ahead taken from options on Eurodollar futures—shown in Chart 6—rose notably in 1994 and 2003, as did implied volatilities on longer-dated swaptions.¹²

Developments in the latter portion of the 2003-2004 episode may be particularly important in thinking about current risks, as FOMC communications about the likely path of the federal funds rate became more explicit after the early summer of 2003. Perhaps because of this forward guidance, long-run federal funds rate expectations (Chart 5) did not move up over 2004 as accommodation was removed, and uncertainty about the policy rate one year ahead (Chart 6) actually moved down. The difference between movements in policy expectations and uncertainty in 2004 relative to those in 1994 or the summer of 2003 are likely due to the fact that FOMC communications about the target rate path were less clear in 1994 and June 2003 than in 2004.

Some technical factors discussed in Section 2 probably also played a role in the different responses of the 10-year Treasury yield over the three episodes. For example, sales of Treasury securities associated with MBS hedging flows or the unwinding of leveraged positions by hedge funds likely amplified the initial rise in interest rates in 1994 and 2003, as the duration of MBS lengthened following the initial rise in long-term yields (Chart 7).¹³ In contrast, MBS duration

¹² On the other hand, the dispersion of long-run federal funds rate forecasts from the Blue Chip survey declined in 1994 and 2003. We think the option-based measure provides a more accurate assessment of the responses of policy uncertainties, as it is available at much higher frequencies than survey forecasts and is a more direct measure of investor uncertainty than survey forecast dispersions.

¹³ As interest rates rise, the prepayment risk in MBS decreases, which in turn leads the duration of mortgage securities to lengthen. To keep the duration of their portfolio unchanged, MBS investors would sell long-term bonds like Treasuries to shed duration, leading to additional declines in bond prices and

shortened as long-term yields edged down after the initial increase in short rates in 2004, potentially contributing to increased demand for Treasury securities and additional declines in term premiums. Long-term yields may have also been held down by increased foreign demand for U.S. long-term obligations at that time.¹⁴ This factor is likely more important in explaining the relatively low level of long-term yields over 2004 and 2005 than it is in accounting for the different behavior of long-term yields in the summer of 2003 and over the course of 2004, as foreign demand for U.S. assets likely did not shift sharply between 2003 and 2004. For example, using the proportion of Treasury securities held by foreign official institutions in custody accounts at the Federal Reserve Bank of New York as a proxy for foreign demand, we find limited shifts over this period.

These findings offer some insight into the likelihood of a substantial increase in long-term interest rates today. Most importantly, the historical behavior of long-term yields depended in large part on the extent to which monetary policy actions were anticipated, and the corresponding evolution of policy uncertainty. Today the FOMC has a larger communication toolkit than in the earlier episodes examined, including much more explicit forward policy guidance, the publication of participants' economic and interest rate forecasts in the Summary of Economic Projections, and the Chairman's post-meeting press briefings. Results from the January 2013 primary dealer survey suggest that market participants currently anticipate that the flow-based asset purchase program will continue into early 2014, and the surveys generally provide a wealth of information about dealers' economic and policy expectations. If in the Committee's view the market is pricing in an amount of policy accommodation that is too high, the Committee can use its communication tools to gradually close the gap between market expectations and its own. On the other hand, the current policy mix, involving both extended forward guidance and shifts in the size and composition of the balance sheet, is historically unprecedented, and the Committee may find it challenging to communicate its plans regarding the removal of accommodation without incurring some degree of confusion among market participants. If such confusion does result, the higher uncertainty about future short-term interest rates could lead to a rise in term premiums on longer-dated securities.

As discussed in Section 2, the Federal Reserve's large holdings of agency MBS, as well as the reduction in holdings at GSEs (which have historically actively hedged their MBS exposures) implies that the amplifying effect of MBS convexity hedging may be less pronounced today than in previous episodes, reducing the risk of a sharp increase in long-term rates. Conversely, recent increases in holdings of MBS by agency REITs, which may come under pressure if MBS yields

increases in bond yields. Julia Fernald, Frank Keane, and Patricia Mosser (1994, "Mortgage Security Hedging and the Yield Curve", *Federal Reserve Bank of New York Quarterly Review*, Vol. 19(2)) argue that this mechanism may have contributed significantly to the amplification of the upward moves in long-term bond yields.

¹⁴ See Ben Bernanke, Vincent Reinhart, and Brian Sack (2004), "Monetary Policy Alternatives at the Zero Bound," *Brookings Papers on Economic Activity*, Vol. 2, 1-100.

rise significantly, could amplify an initial increase in rates. Finally, flows into corporate bond markets were also strong last year. If yields on corporate bonds began to rise unexpectedly, such flows could reverse and possibly strain liquidity, especially for lower-rated bonds. Such strains might boost yields on corporate bonds and adversely affect related markets, although implications for Treasury yields are unclear.

Finally, to provide a broader historical perspective, Table 3 lists all episodes since 1980 during which the 10-year Treasury yield rose more than 100 basis points within a six-month period, and reports the associated changes in the different components of yields, wherever available, and in the macroeconomic forecasts. In all episodes since 1990—when model decompositions of yields became available—most of the yield increases are attributed to higher expected real rates or real term premiums rather than higher expected inflation or inflation risk premiums, consistent with the view that inflation expectations have been low and well anchored during this period. Most of the episodes were not associated with large positive revisions to growth or inflation forecasts by survey participants. It's also worth noting that there were only 6 episodes when yields rose more than 200 basis points, all of which occurred before 1990 when long-run inflation expectations were not as anchored as they are now.

5. The Impact of Current Monetary Policy Strategy

Finally, we consider whether the FOMC's current monetary policy strategy, including the use of LSAPs and the threshold-based forward guidance, is likely to amplify (or reduce) the risk of a substantial increase in long-term interest rates.

Enhanced communications should limit movements in long-term rates reflecting uncertainty about the monetary policy outlook—a factor that, as discussed above, appeared important in 1994 and 2003. Nevertheless, some may be concerned that recent policy changes—asset purchases linked to the labor market outlook and numerical economic thresholds for the federal funds rate—might have increased the sensitivity of interest rates to economic data in a way that, through the various amplification mechanisms discussed above, could contribute to a sharp increase in long-term rates. We find no evidence to date of an increase in sensitivity to economic surprises following the FOMC's policy announcements in September and December 2012 and, in fact, find suggestive evidence that Treasury yields may have become less sensitive to macroeconomic surprises during this period.¹⁵ This is somewhat puzzling, and we view the

¹⁵ In our analysis on this point, we regress changes in forward Treasury rates on measures of the surprise components of several major U.S. macroeconomic data releases, and examine evidence for a break in the sensitivities of forward rates to surprises around the announcement of flow-based LSAPs in September 2012. Using various baseline samples and estimation methodologies—designed, in part, to address the challenges posed by the relatively limited number of post-September 2012 data releases—we do not find evidence that the sensitivities increased. Moreover, wherever significant, the regression results indicate that forward Treasury rates have actually become less sensitive to macroeconomic surprises.

evidence as highly tentative.¹⁶ Even so, while the absence of an apparent increase in sensitivity to macroeconomic surprises may seem to provide some comfort, it may also indicate a reduced likelihood that market reactions to economic developments will move long-term rates in a manner consistent with the likely future path of the target rate. This, in turn, might increase the risk of a substantial increase in long-term rates as market expectations adjust sharply in the future.

We do, however, find evidence that forward Treasury rates have become more sensitive to economic surprises since LSAPs began in late 2008, consistent with market participants' likely inference that bad economic news makes LSAPs more likely and staff analysis showing that LSAPs reduce term premiums. This implies that, going forward, a given change in the expected funds rate path may be associated with larger changes in long-term rates than would otherwise be the case, as expectations for SOMA holdings adjust in tandem with expectations for the funds rate path. To the extent that there are flow effects of purchases, term premiums could also jump when the *flow* of Federal Reserve asset purchases ends, even in the absence of surprises regarding the ultimate size of purchases or path of holdings. However, this seems unlikely to result in large interest rate movements, as such flow effects are estimated to be small and transitory, and the well-telegraphed end of earlier asset purchase programs did not result in notable rate increases.¹⁷

Finally, a rise in interest rates may also be amplified if SOMA portfolio sales lead to large increases in interest rate implied volatilities. For example, according to staff estimates, a \$100 billion surprise in Federal Reserve Treasury purchases has been associated with a contemporaneous decline of about 15 annualized basis points in implied volatility, on average, across maturities and tenors. This likely reflects in part of the constraints imposed by the effective lower bound on interest rates, particularly at short and intermediate maturities. In addition, it could also reflect market participants' assessment of the Committee's reaction function—for example, the belief that the Committee would not tolerate an unwelcome increase in long-term interest rates, a view that would translate into lower interest rate volatility. A shift down in market expectations for the path of Federal Reserve's security holdings may therefore lead to an increase in implied volatility, which may lead leveraged investors to scale back their open positions and push up realized volatility.

¹⁶ Even if the apparently reduced sensitivity is attributable to the policy announcements as opposed to other contemporaneous factors, it is unclear how persistent the effect might be. In particular, rates may become more sensitive to macroeconomic surprises as the thresholds, which are currently quite distant, become more proximate.

¹⁷ Flow effects from Federal Reserve purchases may be more important in the agency MBS market than in the Treasury market, as resulting supply-demand imbalances for specific agency MBS may create "specialness rents" that reduce option-adjusted spreads. For details, see Andrew Howland and Andreas Strzodka, "Relating MBS Specialness Rent to Option-Adjusted Spreads," MarketSOURCE, January 25, 2013.

Chart 1: 10-Year Treasury Yield Forecasts

Quarterly average

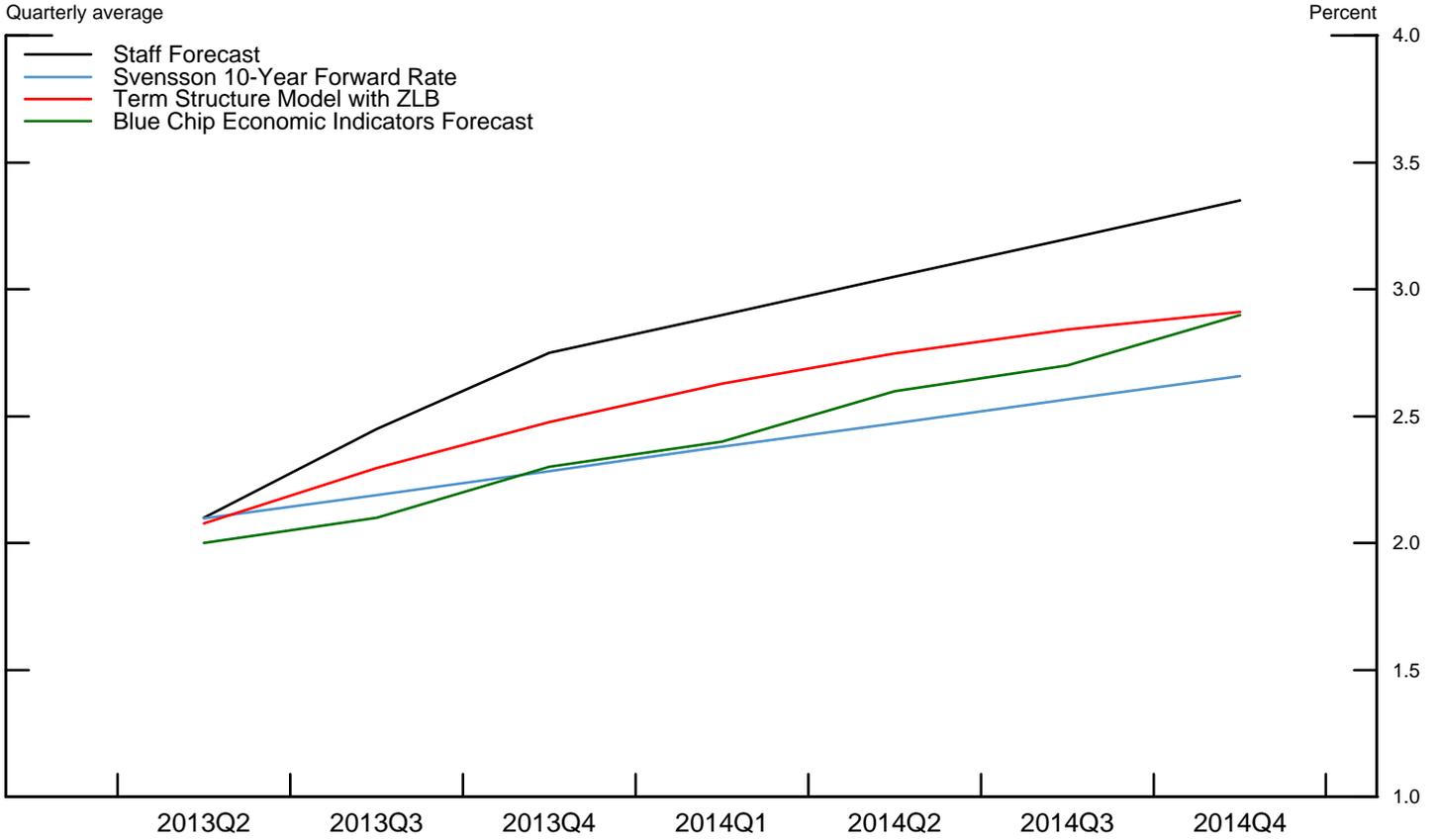
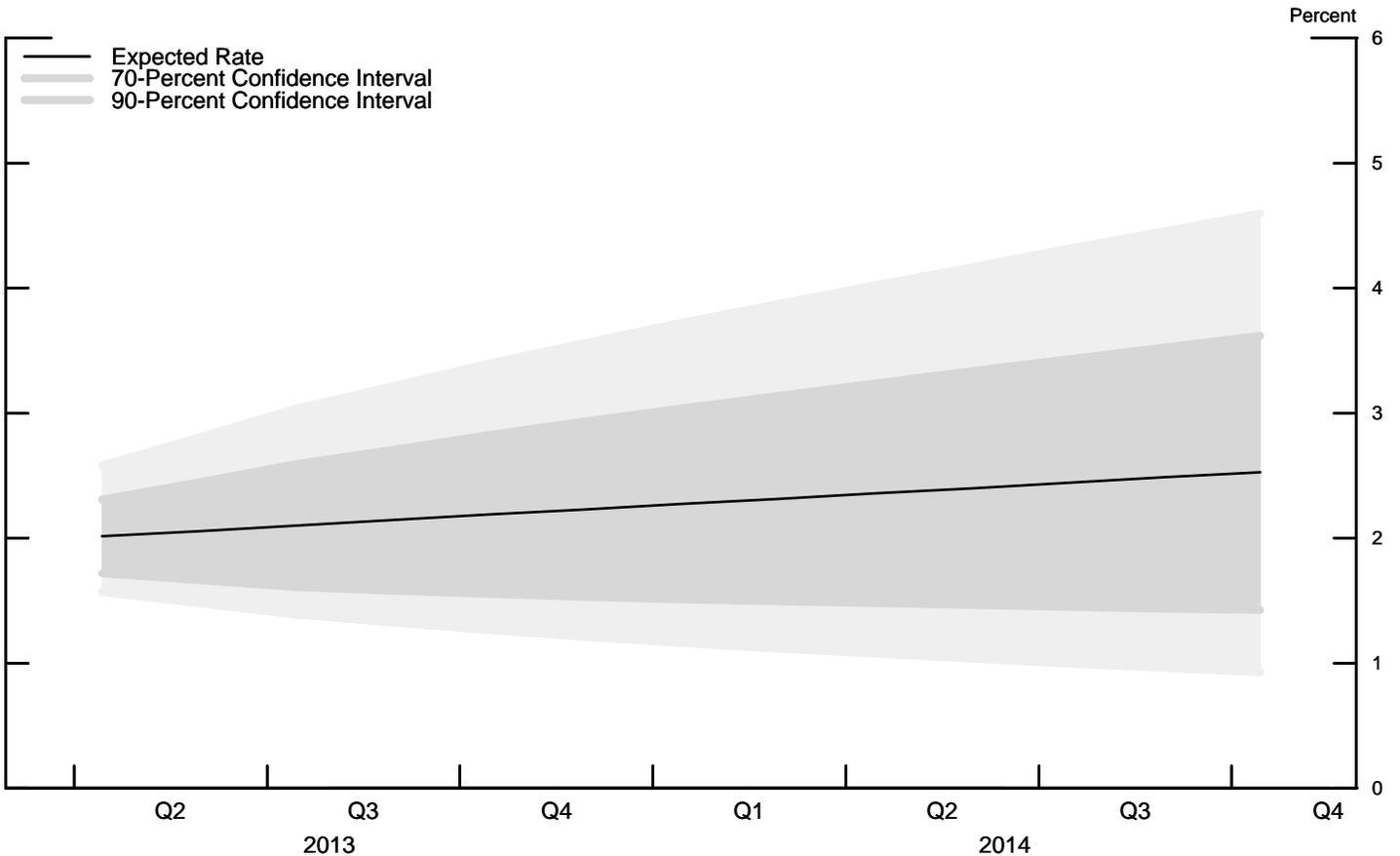


Chart 2: Swaption-Based 10-Year Yield Confidence Intervals



Source: JPM and staff calculations.

Chart 3: Mean Forecasts and 70-Percent Confidence Intervals

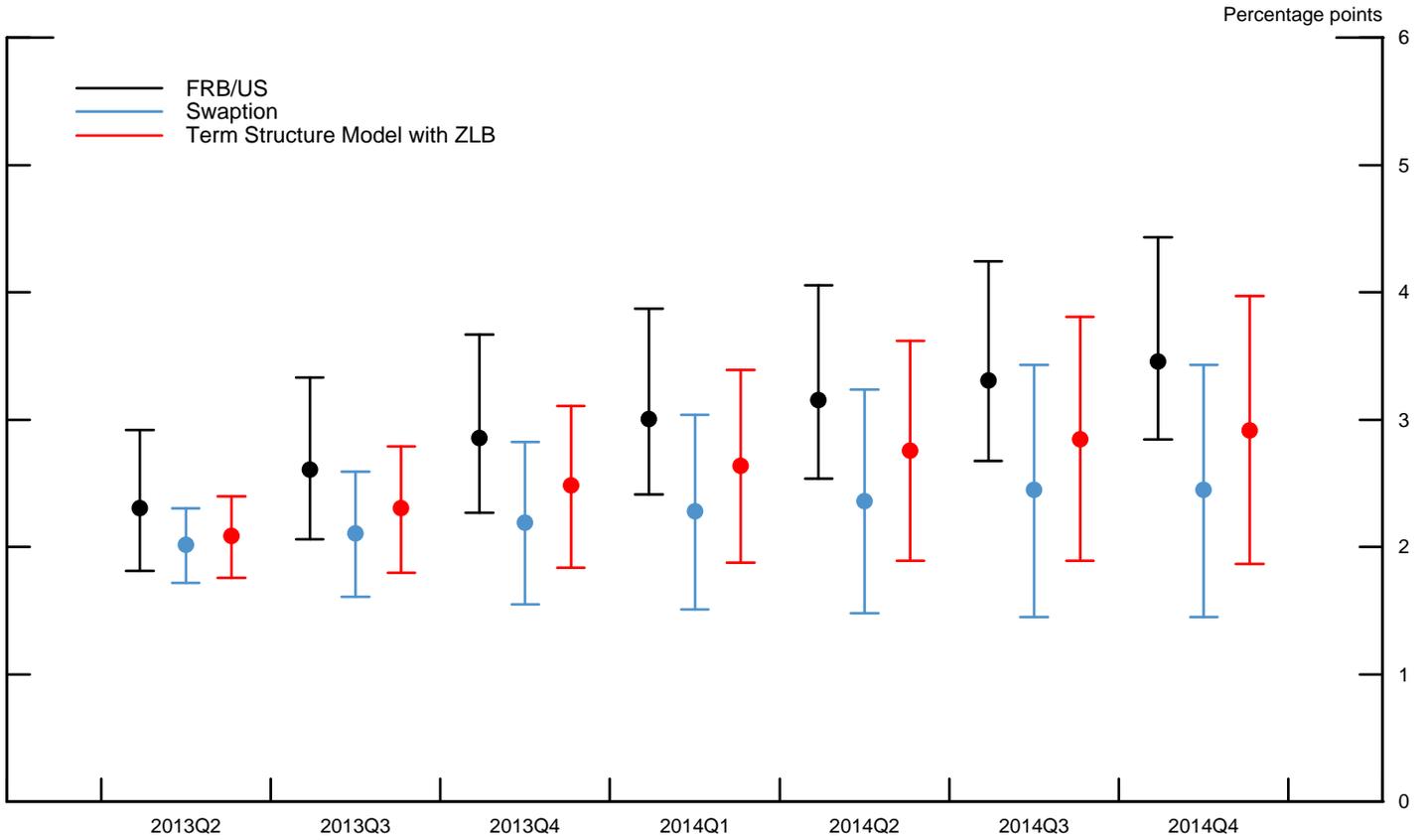


Chart 4: Decomposition of 10-Year Nominal Zero-Coupon Yield from the Term Structure Model with ZLB

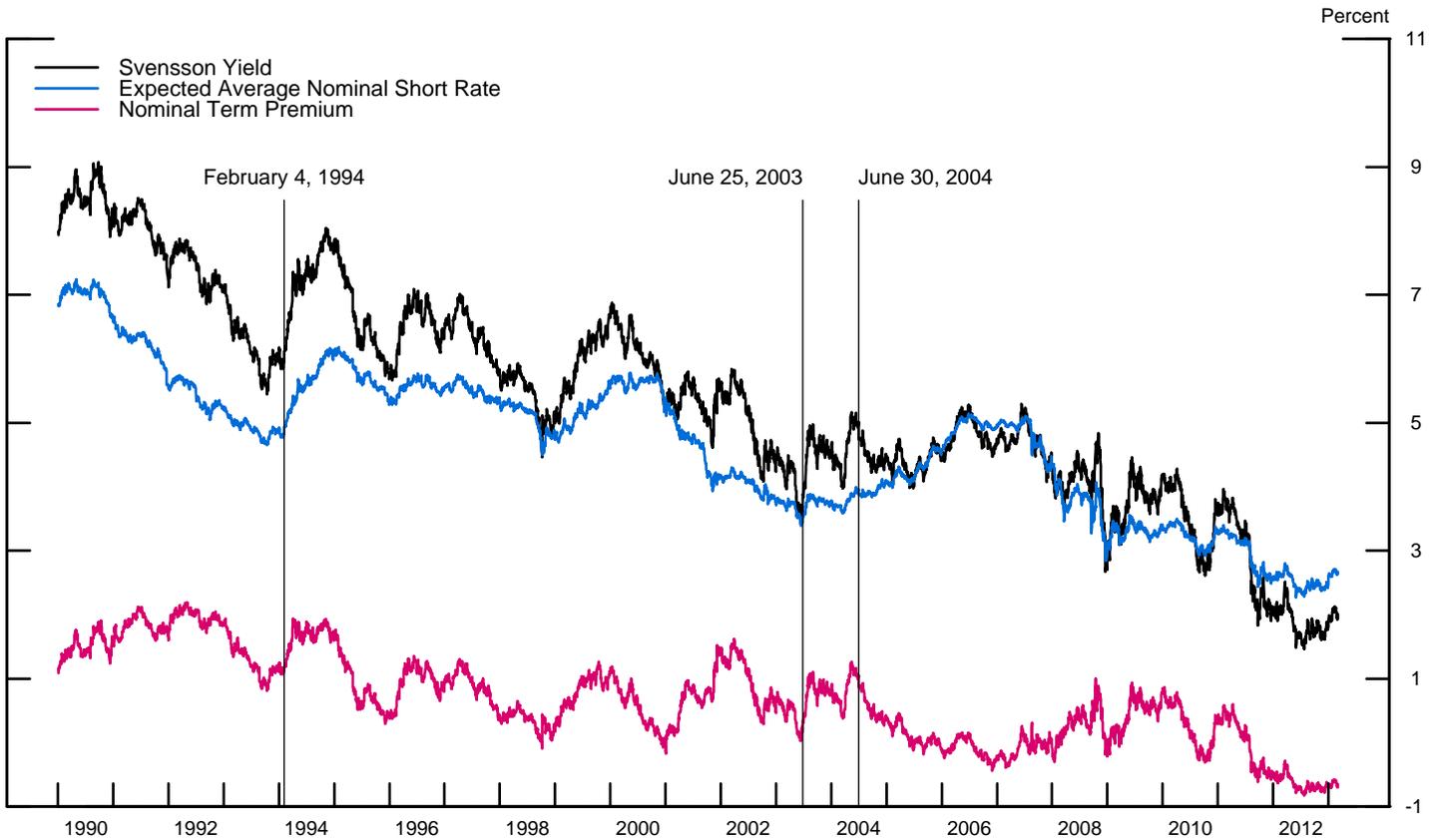
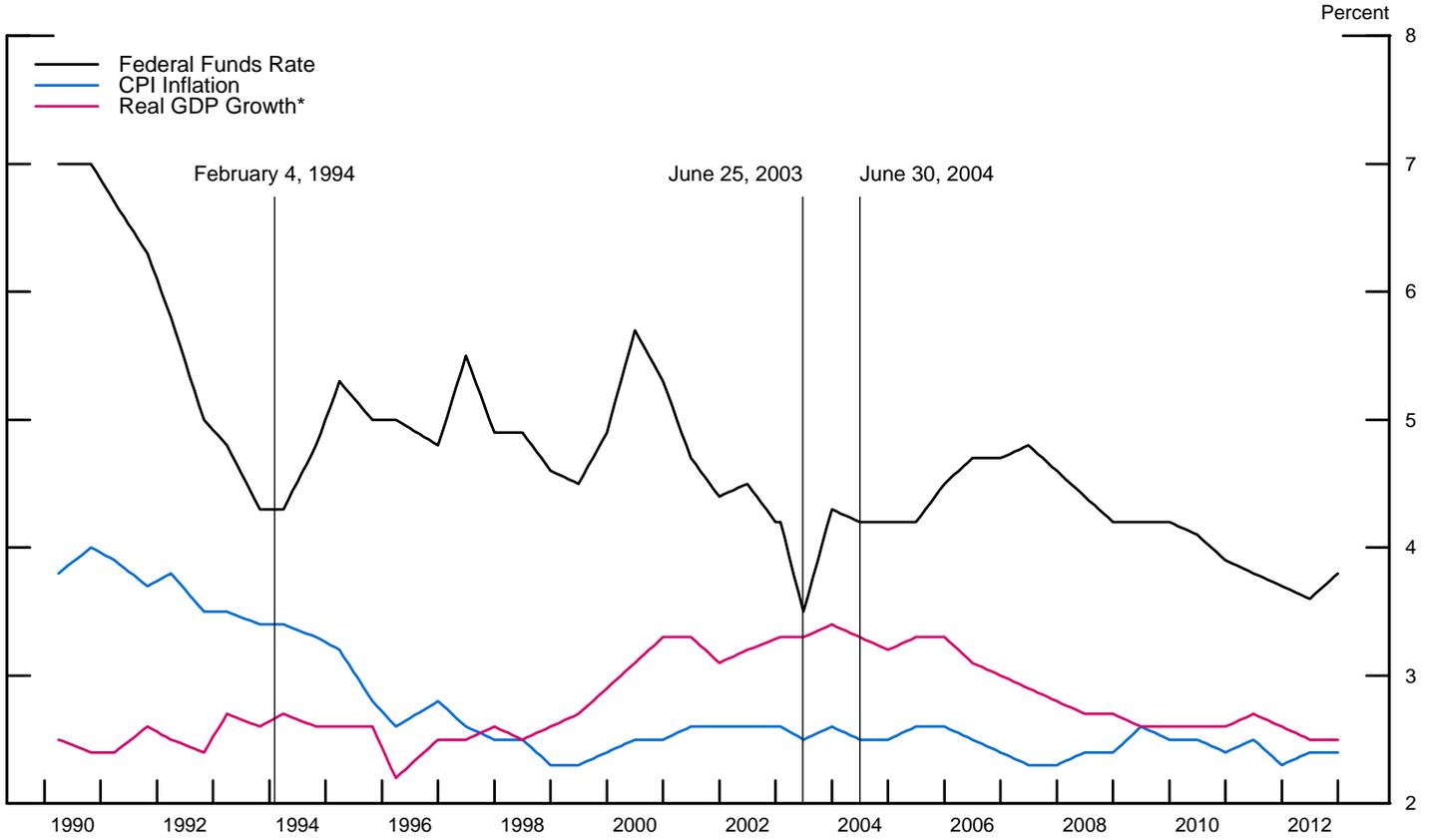
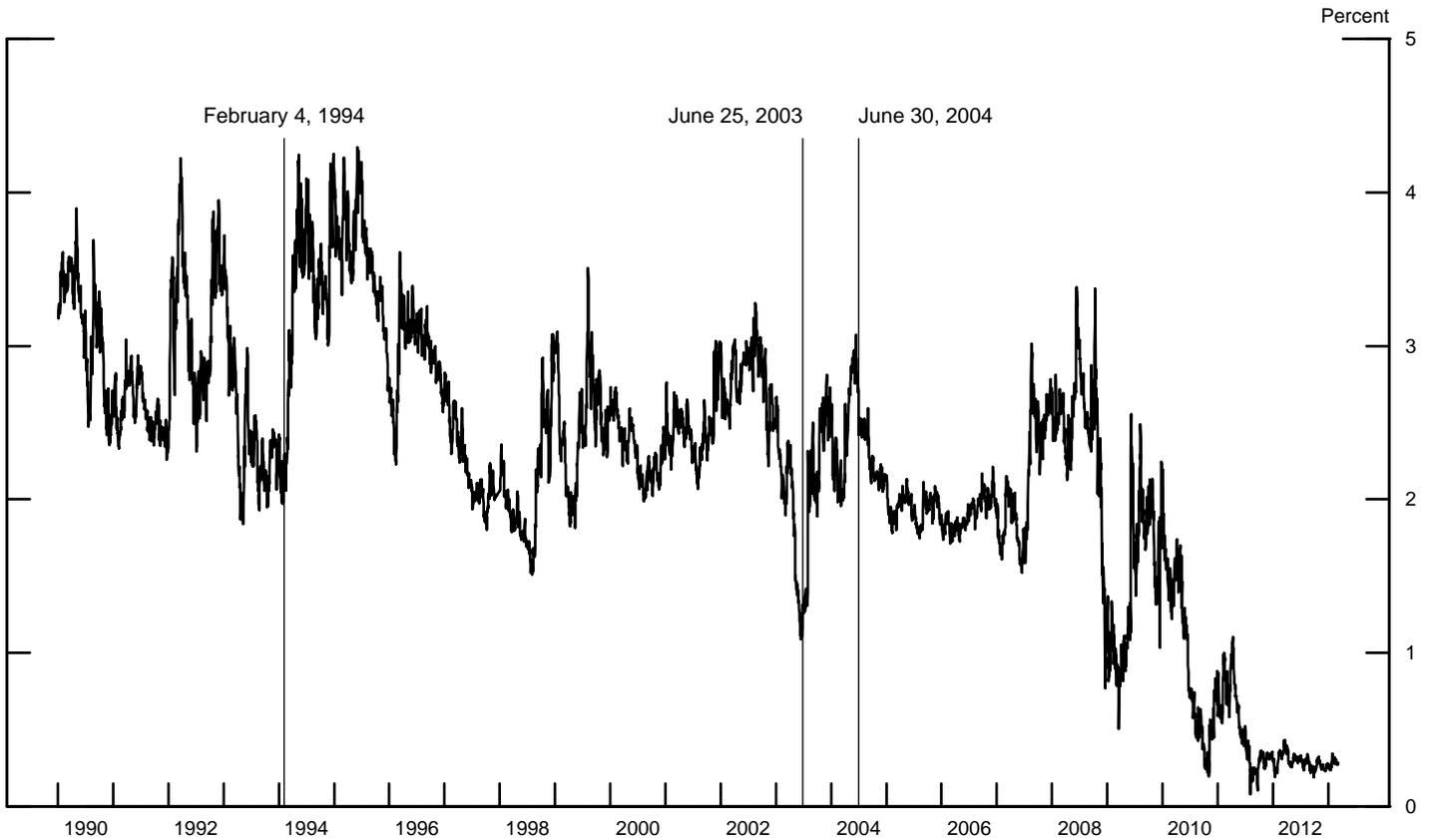


Chart 5: Consensus Long-run Expectations from Blue Chip Financial Forecasts



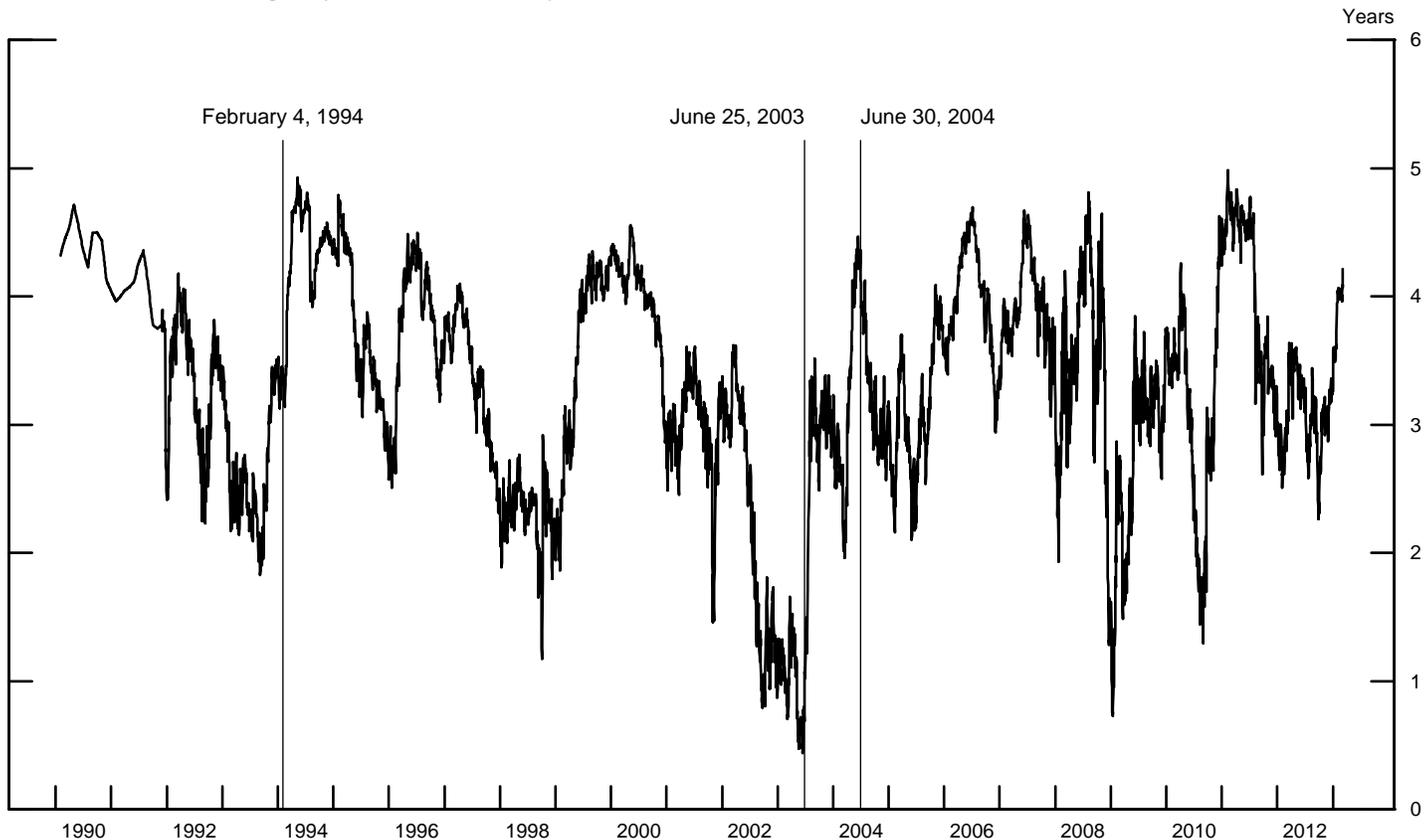
* Real GNP growth before March 1992.

Chart 6: 90-Percent Federal Funds Rate Confidence Interval 12-months Ahead



Source: CME and staff calculations.

Chart 7: Fixed-Rate Agency MBS Modified Adjusted Duration



Source: JP Morgan.

Table 1: Forecasts of 10-year yield at 2014Q4

	Central expectations	Low*	High**	Range***	Average range****
Blue Chip Economic Indicators	2.9	2.3	3.5	1.2	1.3
Swaption	2.5	1.4	3.6	2.2	2.7
Term structure model	2.9	1.9	4.0	2.1	2.4
FRB/US	3.5	2.8	4.4	1.6	

* The average of the ten lowest forecasts for the Blue Chip survey or the lower bound of the 70% interval for all other methods.

** The average of the ten highest forecasts for the Blue Chip survey or the upper bound of the 70% interval for all other methods

*** Defined as High minus Low

**** Historical averages calculated using sample periods going back to 1983 (Blue Chip survey forecasts), 2004 (swaptions), and 1990 (term structure model), respectively.

Table 2: Tail Probabilities of 10-Year Yield at 2014Q4

Panel A: Relative to Staff Baseline (3.5%)

	200 bp below (below 1.5%)	100 bp below (below 2.5%)	100 bp above (above 4.5%)	200 bp above (above 5.5%)
FRB/US	0%	7%	13%	1%
Swaption	17%	55%	6%	2%
Term structure model	7%	37%	7%	1%

Panel B: Relative to Blue Chip Baseline (2.9%)

	200 bp below (below 0.9%)	100 bp below (below 1.9%)	100 bp above (above 3.9%)	200 bp above (above 4.9%)
FRB/US	0%	1%	36%	6%
Swaption	5%	31%	11%	4%
Term structure model	1%	16%	17%	3%

Table 3: Historical Episodes of Substantial Yield Increases*

Start Date	End Date	10-Year Yield			Changes in Components of Yields**				Forecast Revisions***	
		Starting Level	Ending Level	Change	Expected Real Short Rate	Real Term Prem.	Expected Inflation	Inflation Risk Prem.	Real GDP Growth	Headline CPI Inflation
6/11/80	12/11/80	9.58	13.47	3.89					2.63	0.58
1/6/81	2/13/81	11.94	13.41	1.47					-0.15	0.10
3/18/81	5/5/81	12.58	14.60	2.02					0.65	-1.15
6/16/81	9/29/81	12.91	15.66	2.75					0.28	-0.80
11/19/81	2/9/82	12.78	14.81	2.03					0.75	-0.55
5/11/82	6/25/82	13.23	14.46	1.23					-0.05	-0.13
4/18/83	8/8/83	10.46	12.21	1.75					-0.23	0.15
2/3/84	5/30/84	11.59	13.89	2.30					-0.67	0.47
4/16/86	6/4/86	7.25	8.71	1.46					0.08	0.00
3/13/87	5/20/87	7.38	9.04	1.66					-0.35	0.35
6/17/87	10/19/87	8.36	10.22	1.86					-0.13	0.32
12/4/89	4/27/90	7.90	9.14	1.24					0.43	-0.05
1/12/94	5/9/94	5.75	7.55	1.80	0.70	0.59	0.27	0.15	0.18	0.07
6/6/94	11/7/94	6.98	8.08	1.10	0.46	0.35	0.18	0.08	-0.38	0.33
1/18/96	6/12/96	5.67	7.13	1.46	0.37	0.64	0.16	0.18	-0.18	0.00
10/5/98	3/4/99	4.46	5.72	1.26	0.33	0.61	0.15	0.18	0.15	-0.03
11/7/01	12/14/01	4.55	5.55	1.00	0.22	0.56	0.11	0.17	-0.07	-0.13
6/13/03	8/13/03	3.29	4.76	1.47	0.33	0.82	0.17	0.24	0.13	-0.02
3/9/04	6/14/04	3.87	5.03	1.16	0.39	0.45	0.15	0.13	-0.23	0.35
12/18/08	6/10/09	2.58	4.28	1.70	0.37	0.97	0.20	0.28	1.85	0.55
10/6/10	2/8/11	2.51	3.80	1.29	0.27	0.80	0.15	0.23	0.52	0.12

* This table reports yields and macro forecast revisions for all episodes since 1980 during which 10-year Treasury yields rose more than 100 basis points within a 6-month period.

** As implied by a term structure model fitted to nominal Treasury yields, TIPS, and inflation. The period before 1999 when TIPS were not available was treated as missing observations.

*** Changes in forecasts for the next four quarters from Blue Chip Economic Indicators